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Conclusions and Recommendations

The purpose of this chapter is to present specific conclusions and recommendations developed by the individual authors of *Sanitary Survey Update 2001*. As part of the process, the conclusions and recommendations were reviewed for consistency and relevance in a workshop with other report authors. Members of the Sanitary Survey Action Committee (SSAC) then reviewed the draft chapter, and their comments were integrated into the final document.

Conclusions are grouped by chapter and by potential contaminant source (PCS). Report section numbers are provided for each PCS for the reader to reference the section from which the conclusion was drawn. Each section's conclusions are presented consecutively and identified with a lowercase letter, that is, Conclusion a, Conclusion b, etc. Each recommendation appears below the conclusion to which it pertains. Recommendations are not numbered or lettered.

The following chapters do not have conclusions or recommendations: Chapter 1, Introduction and background; Chapter 2, Water Quality Overview; Chapter 11, State Water Project (SWP) Emergency Action Plan.

This chapter does not state a conclusion for every PCS or drinking water parameter, and not every conclusion has a recommendation. On the other hand, some conclusions have multiple recommendations. The goal was to provide a focused set of conclusions and recommendations for priority PCSs that could act as a guide to readers of *Sanitary Survey Update 2001*. Generally, PCSs that were a minor threat to drinking water do not have conclusions and recommendations except in cases where past information had suggested a significant threat to drinking water quality. After the publication of this document, the SSAC will meet to review and prioritize the recommendations for further action. These actions may include increased monitoring or study as well as actions to protect and improve the source waters of the SWP.

CHAPTER 3 BARKER SLOUGH/NORTH BAY AQUEDUCT

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: Studies conducted jointly by the California Department of Water Resources (DWR) and the North Bay Aqueduct (NBA) contractors as well as a recent study conducted by an independent consultant have not identified any single source responsible for the high levels of organic carbon, turbidity, and coliforms. These contaminants continue to create treatment challenges for the contractors treating NBA water. Potential sources of these contaminants include cattle grazing, urban runoff, recreation, and natural processes in the watershed.

Conclusion b: With respect to potential sources of contaminants, the geologic makeup of the watershed may be one of the most important influences on water quality. HydroScience suggested that high sodium content of exposed channels may be the single most important factor in creating the observed turbidity and that the soils and vegetation may naturally lead to higher dissolved organic carbon (DOC) concentrations. Natural background levels of some metals at the Barker Slough Pumping Plant (for example, aluminum or iron) can exceed primary or secondary maximum contaminant levels (MCLs).

Conclusion c: The interactions in hydrology between the Barker Slough watershed, the adjacent Calhoun Cut watershed, the Yolo Bypass, and tidal influences are poorly understood. It has been hypothesized that in the winter, water flowing down Barker Slough as well as Calhoun Cut are trapped in the lower portion of Barker Slough near the pumping plant. Decreased pumping rates combined with poor flushing may then

contribute to high concentrations of contaminants remaining in the vicinity of the pumping plant for long periods of time. This results in a continous source of poor quality water to the NBA contractors. In addition, during high flow years a hydrologic plug may be formed by the Yolo Bypass, which exacerbates these dynamics.

> **Recommendation:** The natural processes of the watershed need to be studied. These include the dispersive and settling properties of the soil and its liberation of organic carbon as well as the role that aluminum and iron may play in enhancing the mobility of organic carbon.
>
> **Recommendation:** Hydrology's role on water quality at the pumping plant needs further study. Soil maps of downstream watersheds need to be examined to determine whether the same general soils found in the Barker Slough watershed are present in nearby downstream watersheds.
>
> **Recommendation:** If natural process in the watershed(s) is primarily responsible for the high total organic carbon (TOC) and turbidity levels, then studies examining the feasibility of pretreatment of NBA source water should be explored as well as other Best Management Practice (BMP) recommendations made by HydroScience, such as the feasibility of source water quality improvements through alternative intake locations, blending, and exchanges.

3.3.1 RECREATION

Conclusion a: The recreational activities at the Cypress Lakes Golf Course and the Jepson Prairie Reserve do not have a significant impact on water quality in Barker Slough. Most recreation in the watershed occurs at the Cypress Lakes Golf Course and the Argyll Park motocross facility. Based on its proximity to the pumping plant and the erosive activities that occur at the motocross park, recreation activities at Argyll Park have the greatest potential impact on water quality.

> **Recommendation**: The transport and fate of contaminants from Argyll Park recreation should be determined.

Conclusion b: In addition to motocross recreation, Campbell Lake at Argyll Park is used by hobbyists and serves as an irrigation pond for the property.

> **Recommendation:** Studies that examine the role played by Campbell Lake in influencing the watershed's water quality should continue. If loading from Campbell Lake or the nearby pond are found to have a significant impact on water quality, then BMPs should be evaluated.
>
> **Recommendation:** Flow measurements should be refined so that loading contributions from the lake during peak storm events can be determined.

3.3.2 WASTEWATER TREATMENT/FACILITIES

Conclusion a: Because of the rural nature of the watershed, the small number of septic tanks, and the low density of septic tanks in the watershed, wastewater is not considered to be a significant source of contaminants to Barker Slough.

3.3.3 URBAN RUNOFF

Conclusion a: A small portion of the upper northwest corner of the watershed is urbanized. Storm drains from approximately 256 acres of the city of Vacaville empty into a drain that leads to the Noonan Main Drain and Barker Slough. The results of special studies suggest that urban runoff is not a major contributor to TOC and turbidity problems.

> **Recommendation:** Flow measurements should be refined so that urban loading contributions during peak storm events can be determined.

3.3.4 ANIMAL POPULATIONS

Conclusion a: A large portion of the Barker Slough watershed is devoted to cattle and sheep grazing. It has been estimated that there are 2,600 to 3,000 cattle and 1,500 sheep in the watershed. Cows are present in the watershed for longer periods of time, and there is substantial evidence of stream bank trampling and animals defecating in the slough. The cattle may be a substantial source of organic carbon, turbidity, and pathogens; however, the relative load of contaminants from cattle and other sources in the watershed is not understood.

Conclusion b: With the exception of the pumping plant itself, fencing along Barker Slough is inadequate to keep livestock out of the slough. Cows have often been observed in the slough, and the banks and wallows used by cows are highly

disturbed. Animals may use the slough because water is unavailable elsewhere.

Conclusion c: High coliform densities are routinely measured at the Barker Slough Pumping Plant. The fecal coliform and *E. coli* densities at the pumping plant are routinely higher than the levels measured at other locations in the SWP (see Chapter 12). The cattle in the watershed are suspected of being a source of the coliforms, and *E. coli* and may be a source of pathogenic microorganisms.

> **Recommendation:** Focused studies on contaminant contributions from livestock need to be conducted.

> **Recommendation:** If cattle are found to be a major source of contaminants, specific BMPs such as the installation and maintenance of fencing along the length of Barker Slough and the installation and maintenance of water sources away from the waterway should be evaluated.

> **Recommendation:** HydroScience recommends that the implementation of other BMPs to reduce bank erosion and livestock control be examined and supported.

Conclusion d: Of the areas grazed in the watershed, only the Jepson Prairie Preserve has a range management plan.

> **Recommendation:** Coordination between water utilities, UC Extension, the Natural Resources Conservation Service, and livestock owners should be supported/pursued to create range management plans for all livestock owners.

> **Recommendation:** A watershed coordinator position should be created to facilitate watershed studies, serve as a contact for information on all watershed management practices, work with the livestock owners and UC Extension on range management plans, insure implementation of BMPs, and serve as a clearinghouse of watershed information.

3.3.5 AGRICULTURAL ACTIVITIES

Conclusion a: Based on contractor Title 22 sample analyses and samples analyzed by DWR, pesticides do not appear to reach levels that are of concern to drinking water. However, sampling frequencies are not correlated to agricultural applications of pesticides. Because row cropping makes up a small percentage of the watershed, the conclusion is that the overall effects of pesticides on NBA drinking water quality are probably minimal.

> **Recommendation:** Any future pesticide monitoring program should consider a pesticide sampling program that realistically mirrors the application of pesticides on row crops.

> **Recommendation:** Where feasible, improve agricultural tailwater conveyance into the drains. This would reduce vulnerability of this drinking water source to pesticide pollution while also reducing off-site transport of sediment and organic carbon.

Conclusion b: Solano Irrigation District (SID) follows strict guidelines to minimize off-site movement of pesticides. To control unwanted vegetation, SID is in the process of allowing revegetation of grass along the banks of some drains.

> **Recommendation**: SID's bank stabilization through revegetation should be supported. The sediment contribution from unpaved SID-maintained roads to access the Noonan Main Drain for weed control should be examined.

CHAPTER 4 THE DELTA

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: Monitoring at Banks Pumping Plant detected herbicides, arsenic, copper, zinc, and manganese. All were at concentrations significantly below regulatory levels for treated drinking water.

> **Recommendation:** Periodic monitoring of selective pesticides and other regulated and unregulated chemicals based on use, environmental fate, solubility, and other properties should be conducted with review by the Department of Health Services (DHS) and SWP contractors.

Conclusion b: Taste and odor problems in the South Bay Aqueduct (SBA) result from a combination of algal production in Delta source waters entering at Banks and in the open portions of the SBA. Algae continue to grow in the SBA open canal during favorable growth conditions that generally occur during the warmer months.

> **Recommendation:** See recommendations under Chapter 5 review, Section 5.3.1.5.

4.2.1 RECREATION

4.2.1.1 Recreational Use Surveys

Conclusion a: No current study exists that documents the number of recreational users, length of visits, number of dollars spent per visitor day, age, sex, etc., on recreation use visits, or types of facilities needed to meet present or future visitor needs for the entire Delta. The most recent study, commissioned in 1995 by the Delta Protection Commission, focused on boating and fishing because these are the most popular uses of the Delta.

> **Recommendation:** A central information agency/repository is needed to collect, collate, and analyze visitor days, number of visitors, number and type of restrooms, types of facilities, etc. on all public and private recreational facilities throughout the State.

Conclusion b: A recreation survey conducted by DWR in 1980 is considered one of the best recreational use surveys of the Sacramento River. No recreation use surveys were found for the San Joaquin River.

> **Recommendation:** Recreational use surveys for the Delta and the Sacramento River need to be updated. The San Joaquin River Management Plan recommended a recreational use survey of the San Joaquin River in 1995; however, no action has been taken. Performance of this survey should be encouraged.

Conclusion b: Based on a 1995 survey, the west Delta (including the lower Sacramento and San Joaquin rivers, and the Brannan Island State Reserve) is the most popular area in the Delta for boating and fishing as well as nonboating activities like swimming.

> **Recommendation:** If funding is limited, priority should be given to upgrades of restroom facilities in recreation areas and educational programs in the west Delta.

> **Recommendation:** Funding needs to be provided to carry out the aforementioned recreation-use recommendations.

4.2.1.2 Boating and Pathogen Contamination

Conclusion a: Congress found that "sewage discharged from recreational vessels because of an inadequate number of pump-out stations is a substantial contributor to localized degradation of water quality in the U.S." The Water Quality Control Plan for the Central Valley region also prohibits the discharge of toilet wastes from the vessels of all rental houseboats in the Delta. Chapter 6 of the Harbors and Navigation code mandates that all marinas must have pump-out facilities.

Conclusion b: In practice, many marinas have no pump-out facility. In the Delta area, as many as 70% of all marinas may not have a pump-out facility.

> **Recommendation:** Education efforts for marina users and the general public conducted by the California Department of Boating and Waterways (DBW) and other agencies need to be continued and expanded to inform the public on the need for using pump-out facilities and the problems with inappropriate disposal.

> **Recommendation:** Support a strong education program on the Pumpout Grant Program, which will reimburse recipients for up to 75% of the installed cost of pump-out and dump stations.

Conclusion c: Because of staffing limitations at the Central Valley Regional Water Quality Control Board (CVRWQCB), the pump-out requirement is minimally enforced.

> **Recommendation:** Additional staff needs to be added to the CVRWQCB to allow better enforcement of pump-out regulations.

Conclusion d: The most popular boats used in the Delta (powerboats) generally do not have Marine Sanitation Devices (MSDs).

Recommendation: The feasibility of installation of type III MSD devices on all powerboats above a certain size class should be investigated.

Conclusion e: Although small in volume, boat sewage is highly concentrated. The DBW estimates that a single weekend boater flushing untreated sewage into the water produces the same amount of bacterial pollution as 10,000 people whose sewage passes through a treatment plant.

Conclusion f: In addition to fecal contamination, some of the chemicals used for MSD disinfectants include chlorine, ammonia, and formaldehyde. These constituents are also discharged when boaters empty an MSD directly into the water.

Recommendation: Education efforts for marina users and the general public conducted by the DBW and other agencies need to be continued and expanded to educate the public on the problems associated with inappropriate disposal of boating sewage.

Conclusion g: Boat MSDs frequently have a Y valve that allows boaters to direct wastes either to a holding tank or overboard. Boats operating in the Delta or other inland waters must secure the Y valve handle in the closed position with a wire tie or padlock. Overboard discharges frequently are caused by intentional or unintentional misuse of the Y valve.

Recommendation: Existing regulations and legislation regarding the modification of the Y valve on MSDs to minimize accidental release of waste material need to be evaluated.

4.2.1.3 Body-Contact Recreation and Pathogens

Conclusion a: In the Delta, most body-contact recreation is centered on waterskiing and windsurfing. Because of the lack of public beaches, swimming from shore is limited; therefore, swimming from a boat is more popular.

Conclusion b: Results from the most recent survey of existing on-shore restroom facilities in the Delta suggest that the number of facilities are inadequate.

Conclusion c: No data are available that correlate pathogen numbers with recreation use in the Delta. Even if sewage originates from a human source, it is difficult to know whether it comes from a boat, swimming from shore, a malfunctioning septic system, or a wastewater treatment plant. Under these circumstances, the best strategy may be prevention through installation of MSDs, pump-out facilities, and restrooms.

Recommendation: More restroom facilities are needed on shore and on the water. More pump-out facilities and MSDs are also needed for swimmers who choose to swim from boats.

Recommendation: Education programs at public beaches need to be expanded. Public outreach at schools might also be helpful.

Conclusion d: Bacteria sampling of freshwater public beaches is generally sporadic or nonexistent.

Conclusion e: Without accurate use numbers and with sporadic coliform sampling by local agencies at Delta recreation areas, it is not possible to draw conclusions on body-water contact and pathogens.

Recommendation: Local health authorities should be contacted to discuss options for increasing bacteriological monitoring of Delta waters used for recreation.

4.2.1.4 Delta Recreation and MTBE

Conclusion a: MTBE is a fuel additive to boost octane and make gasoline burn more efficiently.

Conclusion b: Carbureted 2-stroke outboard engines can discharge up to 25% of their unburned fuel/oil mixture (including MTBE and hydrocarbons) through their exhaust into the surface water.

Conclusion c: Outboard 2-stroke direct fuel injection engines and 4-stroke inboard and inboard-outboard engines burn fuel more efficiently and do not discharge large amounts of unburned fuel into the water through their exhaust. Four-stroke engines burn fuel more efficiently than 2-stroke direct injection engines.

Conclusion d: Starting in 2001, the California Air Resources Board (CARB) has enacted regulations reducing allowable emissions from outboard motors and personal watercraft (PWC). These regulations will also serve to reduce the discharge of unburned fuel into surface waters.

Conclusion e: Beginning in 2001, 2-stroke direct fuel injection engines will be sold. Carbureted 2-stroke engines will not be sold.

Conclusion f: The CARB regulations do not require retrofitting or replacement of pre-2001 model year engines.

> **Recommendation:** Encourage CARB to create a buy-back program to remove pre-2001 model year carbureted 2-stroke engines from use. Coordinate and cooperate with the CARB and marine engine manufacturers on this issue.

Conclusion g: MTBE as a gasoline additive is being phased out by 2002; however, the phaseout is complicated by the federal ruling that mandates oxygenates in fuel.

Conclusion h: A recent evaluation of MTBE in Delta surface waters determined that, based on its low concentrations, MTBE in Delta waters was of limited significance to drinking water.

> **Recommendation:** To minimize contamination, all MTBE sampling should be conducted from a boat with a 2-stroke direct injection engine, 4-stroke engine, or an engine filled with non-MTBE gasoline.

> **Recommendation:** MTBE results need to be reported to DHS. DHS and the CVRWQCB should work together to devise MTBE basin plan limits.

4.2.2 WASTEWATER TREATMENT FACILITIES

Conclusion a: Data collected by wastewater treatment plants (WWTPs) are generally insufficient for evaluating impacts on drinking water quality. Data are collected to comply with the National Pollutant Discharge Elimination System (NPDES) permits, which do not always include drinking water parameters of concern.

> **Recommendation:** WWTP sampling should include analyses of components important to drinking water such as TOC/DOC, nutrients, pathogens, chromium 6, and mercury.

> **Recommendation:** Encourage development of nutrient export coefficients and nutrient loading data from WWTPs.

> **Recommendation:** Continue to review and comment on CEQA documents for expansion of existing WWTPs and construction of new plants.

> **Recommendation:** Analyses should be conducted on the cumulative impact on Delta water quality of contaminant loading from WWTPs.

4.2.3 URBAN RUNOFF

Conclusion a: Urban runoff is increasing in the Delta watersheds, including at sources close to drinking water diversions. Current monitoring is conducted to comply with a NPDES general storm water permit. Data are not required to be collected to assess the impacts to drinking water quality. Existing information shows extreme peaks that are episodic in nature for bacteria, carbon, and other drinking water parameters of concern.

> **Recommendation:** As part of their storm water permit monitoring program, agencies should be required to collect data for drinking water parameters of concern.

> **Recommendation:** Even if drinking water parameters are added to storm water permits, the frequency of permit sampling may not adequately assess drinking water impacts. Therefore, specific studies should be developed to examine the impacts of storm water runoff on drinking water, including sampling major pumping stations during storm events to monitor contaminants flushed to the Delta.

> **Recommendation:** Assessments of impacts from urban loading should be used to determine whether controls should be pursued. Size of discharge, proximity to drinking water intakes, and runoff sources should be evaluated.

4.2.4 LIVESTOCK GRAZING

Conclusion a: As urbanization is increasing, grazing as a land use is stable or decreasing. San Joaquin County shows the highest density of animals per acre.

> **Recommendation:** Support the California Cattlemen's Association, UC Cooperative Extension, and other range management efforts to reduce impacts to the watershed through BMPs. Support CALFED's efforts to potentially assess the findings of these individual programs.

4.2.5 CONFINED ANIMAL FEEDING OPERATIONS

Conclusion a: There was a lack of reliable data on locations of confined animal feeding operations (CAFOs), which constrained production of accurate distribution maps for *Sanitary Survey Update 2001*. In the CAFO database available from the California Department of Food and Agriculture (CDFA), some facilities data included street addresses. Others only had owner address, which could be in a different county from the CAFO location. Therefore, the distribution maps in this report should only be considered to represent approximate CAFO locations. (EPA Region 9 has Geographic Information System (GIS) data for large dairies with 1,000+ animals, but these are only a subset of the total CAFOs in the watersheds.)

> **Recommendation:** Initiate acquisition of geo-referenced spatial data (latitudes and longitudes) to create more accurate CAFO distribution maps.
>
> **Recommendation:** Explore potential for CVRWQCB and DWR cooperating to acquire necessary spatial data. Informally, CVRWQCB had indicated that it would start collecting GPS data when its funding allows.
>
> **Recommendation:** Ensure that GIS data has appropriate metadata. CVRWQCB would likely collect facility location at lagoons, which are the potential points of discharge, whereas EPA collects GPS data at the milk house. On a large dairy, the milk house and lagoon may be widely separated, and the facility spatial depiction derived from the 2 methods may appear significantly different when plotted (depending on the map scale).

Conclusion b: There is a lack of water quality data from CAFO discharges. CVRWQCB mostly collects ammonia and electrical conductivity (EC) data at accidental/illegal discharge locations. There are no regularly scheduled programs to monitor water quality in areas with heavy CAFO concentrations. The impacts of land applications of wastewater and biosolids, which may contribute nutrients, pathogens, TOC, etc. into storm water runoff that drain into Delta tributaries, is unknown.

> **Recommendation:** Initiate coordination with other agencies that have an interest in CAFO operations such as CVRWQCB, DHS, EPA Region 9, California Department of Pesticide Regulations, county agencies and UC Extension (which manages agricultural and range water quality). Coordination could reduce duplication of efforts and better implement control measures.
>
> **Recommendation:** Establish cooperation with CVRWQCB to collect geo-referenced samples that can be analyzed for TOC/DOC, nutrients, total dissolved solids (TDS), minerals, emerging contaminants, and pathogens. The data will provide a preliminary evaluation of the CAFO waste discharge problem in the watersheds and also help in designing subsequent detailed studies. Funding for this additional work should be sought through the CALFED Bay-Delta Program.
>
> **Recommendation:** Encourage development of nutrient loading for CAFOs in the watersheds. The Delta watersheds export nutrients that promote algal growth in the SWP. From this data, nutrient export coefficients should be derived and used to model relative contributions of different land use types to water body eutrophication.

Conclusion c: Current staff funding at the CVRWQCB is inadequate to identify all the CAFOs that illegally discharge into Delta tributaries.

> **Recommendation:** To successfully support the quality of SWP supply sources, increased staff levels should be required to identify any illegal discharges.

4.2.6 AGRICULTURAL DRAINAGE

4.2.6.2 Delta Agricultural Drainage

Conclusion a: Delta island drainage is a significant source of organic carbon.

> **Recommendation:** Support CALFED program studies of methods to protect Delta drinking water quality. Some of these actions include re-routing drainage discharge locations, treating drainage to reduce TOC, and timing storage and releases to maximize dilution.

Conclusion b: When Delta water is siphoned onto the islands for irrigation, bromide from seawater intrusion is transported onto the fields and then returned back into the channels in drainwater. Some

bromide may be released from decaying peat and plant matter.

Conclusion c: Delta island drainage is high in TDS, EC, and other salts because of evaporation of applied irrigation water and, for some islands, connate water.

Conclusion d: Pesticides from applications to Delta island crops do not appear to be a significant contaminant at the Banks headworks. When found, they are well below MCLs for drinking water.

Conclusion e: The contribution of nutrients from Delta island drainage is poorly understood because of lack of data. Applied nutrients and those from decaying peat and crop mass may be a significant source of nutrients that can stimulate algal growth at SWP reservoirs.

> **Recommendation:** Begin selective monitoring of nutrient loads from Delta island drains.

Conclusion f: Future development in and upstream of the Delta, including new or enlarged diversions and storage projects may impair Delta flows and reduce drinking water quality.

> **Recommendation:** Ensure proposals for future developments in and upstream of the Delta—such as new diversions and storage projects—are thoroughly evaluated to assure they do not impair flows and reduce water quality.

4.2.6.3 Sacramento River Basin

Conclusion a: Significant amounts of pesticides are used on 2 million acres of crops in the Sacramento River Region. Colusa Basin Drain (CBD1) and Sacramento Slough capture 80% of the agricultural drainage. Monthly sampling over an 18-month period detected a number of pesticides, with the majority being herbicides. None were detected above the MCL set for treated drinking water. Pesticides at measured levels are not a significant threat to drinking water quality.

Conclusion b: Nitrogen and phosphorus are found at higher concentrations in the drains than in the Sacramento River. Sacramento agricultural drainage provides a significant amount of nutrients. Nutrient loading from agricultural drains affects the Sacramento River concentrations from winter through early summer, but the impact to the water quality at Delta drinking water intakes is unknown.

> **Recommendation:** Nutrient loading to the Sacramento River from various sources should be monitored. New or expanding nutrient sources should be identified, and control measures encouraged.
>
> **Recommendation:** An analysis of the seasonal impact of nutrients should determine whether effects at Banks are great enough to warrant pursuing source evaluation and possible control.

Conclusion c: EC values are 4 times higher in CBD1 than in the Sacramento River. EC readings show an inverse relationship to flow. During periods of low flow such as in the late summer through early winter, concentrations of salt in the river are measurably increased by agricultural drainage.

Conclusion d: Organic carbon concentrations in the agricultural drains discharging to the Sacramento River ranged from 2 to 10 mg/L, while the receiving water averaged below 2 mg/L. As river flows decrease in the summer, fall, and early winter, agricultural drainage provides an increased portion of the TOC load, as high as 30%. Concentrations in the river are increased during this time by the agricultural drainage.

> **Recommendation:** An analysis of the seasonal impact of carbon loading should determine whether effects at Banks are great enough to warrant pursuing source evaluation and possible control.

Conclusion e: A shift from burning of rice stubble to decomposition by flooding may increase carbon loading.

> **Recommendation:** Track rice acreage subjected to flooding and correlate with measured organic carbon concentrations at key locations to determine whether a trend exists. If this analysis indicates a possible trend, further investigation leading to improved control should be implemented.

4.2.6.4 San Joaquin River Basin

Conclusion a: Significant amounts of pesticides are used on 2 million acres of crops in the San Joaquin River Region. Monthly sampling over an 18-month period detected a number of pesticides, the majority being herbicides. None were detected above the MCL for treated drinking water; consequently, this water when treated would not have higher

concentrations. Pesticides at measured levels are not a significant threat to drinking water quality.

Conclusion b: Nitrogen and phosphorus are found at higher concentrations (roughly 3 times greater) in the San Joaquin River than in the Sacramento River. Less dilution flows, wastewater treatment plant and confined animal facility discharges, and recirculated nutrients from the west side of the San Joaquin Valley contribute to the San Joaquin River's higher concentrations.

> **Recommendation:** Nutrient loading from various sources should be monitored in the San Joaquin River. Existing, new, and expanding nutrient sources should be identified and control measures encouraged.

> **Recommendation:** Coordination with the San Joaquin River Dissolved Oxygen TMDL (total maximum daily loading) Development Group Deep Water Ship Channel project should include addressing drinking water concerns through sharing of related nutrient data.

Conclusion c: Though Mud and Salt sloughs account for less than 10% of the mean annual discharge to the San Joaquin River, they account for over 40% of the TDS load. Salt is recirculated through the Delta-Mendota Canal (DMC) and then reapplied to the west side of the region. CAFOs and publicly owned treatment works (POTWs) in the region are also sources of salts. Control of agricultural drainage from Mud and Salt sloughs would result in lower TDS concentrations in the lower San Joaquin River. Salt control measures implemented in the San Joaquin River Basin would probably improve water quality at the Tracy Pumping Plant and, to a lesser extent, at Banks Pumping Plant.

> **Recommendation:** The San Joaquin Valley Drainage Implementation Program and CALFED need to address the impacts to Delta export drinking water quality when exploring drainage control measures to meet existing standards for ecosystem water quality. CALFED recommends the following control measures for salts in the San Joaquin Basin: treat drainage, relocate discharge points, release drainage during ebb tidal flows, manage frequency of leaching, implement BMPs, or modify land management practices to reduce loadings of TDS. Support land retirement programs for drainage-impaired lands with local sponsorship.

> **Recommendation:** Additional data should be collected on contaminants and contaminant loads from Mud and Salt sloughs. These findings should be confirmed by concurrent monitoring of flow and TDS in the San Joaquin River and Mud and Salt sloughs. It is unlikely that the Mud and Salt Slough drainage will be removed from the river, but the additional data may be useful in recommending BMPs to improve the quality of the drainage water.

> **Recommendation:** The potential of more efficient irrigation practices and drainage programs to reduce bromide and salt loads should be evaluated. Use of incentives such as grants and low-interest loans for drainage reuse, drainage reduction, and improved irrigation efficiency should be considered.

Conclusion d: Organic carbon concentrations are significantly higher in the San Joaquin River than in the Sacramento River. Very little source water quality data for organic carbon are available for the San Joaquin River, except at Vernalis. The river contributes to elevated carbon concentrations in the SWP.

> **Recommendation:** Source water quality data should be collected to determine the relative organic carbon sources in the watershed. The San Joaquin Valley Drainage Implementation Program and CALFED need to examine the potential benefits of pulse discharges and other agricultural drain management programs designed for salt control on carbon concentrations and Delta exports.

4.2.7 GEOLOGIC HAZARDS

Conclusion a: Earthquakes pose a catastrophic threat to Delta levees. A levee failure in the central or western Delta could disrupt or interrupt water supply deliveries, transportation, and the regional flow of goods and services. The effects of salinity intrusion from levee failure would be intensified if the seismic event occurred during a period of low river flows and/or during a high tide.

> **Recommendation**: Support the CALFED Levee System Integrity Program Plan to protect levees from failure.

4.2.8 SEAWATER INTRUSION

Conclusion a: Seawater intrusion is the most significant source of EC, TDS, and bromide to Delta waters. Its contribution to organic carbon and nutrient loads at the intake pumps is unknown.

Conclusion b: Based on available data, neither connate (trapped seawater groundwater of ancient origins) nor methyl bromide used in Delta watersheds plays a significant role in Delta bromide levels.

Conclusion c: Next to seawater, the San Joaquin River may be the most important contributor of salts and bromide to the Delta, but both constituents reflect the recirculation of salts and bromide originally introduced to the San Joaquin Valley from Delta waters. Additionally, salt loading may reflect salt leaching of naturally saline subsurface soils.

Conclusion d: Since bromide and TDS are largely a function of seawater intrusion, diverting or repelling seawater would require substantial reconfiguration of general Delta flows. Substituting cleaner source water is another option being considered by CALFED as improving treatment capabilities for Delta water users. Anthropogenic sources of salt are also subject to some degree of control.

> **Recommendation:** Programs encouraging voluntary exchanges or purchases of high-quality source waters should continue to be supported.
>
> **Recommendation:** Support CALFED's efforts to improve source water quality and provide assistance to water treatment plants (WTPs) to improve their existing plants or to construct new facilities to meet new disinfection byproduct (DBP) and pathogen regulations. Additional recommendations made by CALFED to evaluate and improve Delta drinking water quality should be supported as appropriate.

Conclusion e: Of the TDS loading occurring in the Sacramento River, it has been estimated that depending on the year approximately 26% to 33% comes from agricultural drainage while approximately 6% comes from urban runoff. The majority of TDS sources are unknown. Depending on the year, between 79% and 100% of all of the TDS in the San Joaquin River can be traced to Mud and Salt sloughs with only 21% coming from unknown sources.

CHAPTER 5 SOUTH BAY AQUEDUCT AND LAKE DEL VALLE

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: Organic carbon and bromide are 2 major water quality concerns for all SBA contractors. Concentrations of these constituents are largely out of contractors' control because of their presence in Delta source waters.

> **Recommendation:** CALFED's efforts to improve source water quality and provide assistance to water utilities to improve their existing treatment plants or construct new facilities to meet new DBP and pathogen regulations should be supported.

Conclusion b: There are several contaminant sources and related water quality problems (for example, recreation/grazing and pathogens, boating and MTBE, algae and taste and odor) that are of concern in Lake Del Valle, the analysis of which would greatly benefit from an integrated watershed management program approach.

> **Recommendation:** A watershed management program (WMP) should be initiated at Lake Del Valle to coordinate existing and future watershed management activities and studies. Funding and support for a watershed coordinator position should be investigated and obtained if possible. The WMP staff should act as contacts for information on all watershed management practices and provide a clearinghouse of watershed information (recreational use, cattle grazing, sewage system operation, etc.).
>
> **Recommendation:** A comprehensive study should be made of the major sources of nutrients to Lake Del Valle and the SBA. The study should address algal dynamics and nutrient cycling in Lake Del Valle and the open sections of the aqueduct to better understand the processes controlling algal blooms. The study should include correlation of algal growth and taste and odor data with SBA delivery times and natural lake inflows. If the study finds significant local inputs of nutrients, a local source reduction program should be implemented. This study should also be coordinated with and include, if applicable, other studies undertaken for pathogens, MTBE, or other contaminants.

5.3.1 SOUTH BAY AQUEDUCT

5.3.1.1 Recreation

Conclusion a: There is no authorized recreation activity along the open sections of the SBA; therefore, it constitutes a minimal threat to water quality.

5.3.1.2 Wastewater Treatment/Facilities

Conclusion a: There are no known or reported wastewater treatment facilities or effluent discharges to the open sections of the SBA. There is one septic tank and leach field at the South Bay Pumping Plant. This is not considered a significant potential source of pathogens.

5.3.1.3 Urban Runoff

Conclusion a: There is very little urbanization in this section; therefore, urban runoff into the open section of the aqueduct is not significant.

5.3.1.4 Animal Populations

Conclusion a: Cattle graze along the open portions of the SBA. Runoff from surrounding hillsides can enter the open portions of the SBA through drain inlets, overcrossings, and bridges. The open portions of the SBA are fenced so this is not a direct source of contamination. Grazing is considered a significant potential source of pathogens and nutrients in the SBA.

A major route of contamination was via wooden bridges used by cattle to cross the aqueduct, and large gaps on these bridges allowed cattle wastes to directly enter the aqueduct. The wooden planks were replaced with sealed flooring to reduce impacts to water quality and are routinely inspected and repaired as necessary. Although bridge repair greatly reduced the overall impact of grazing by eliminating wastes from this source, cattle wastes from hillside grazing can still enter the SBA via runoff into drain inlets.

> **Recommendation:** DWR should conduct a feasibility study to redirect inlet drainage away from the SBA. Every effort should be made to direct hillside drainage in grazing areas away from the open portions of the SBA.

5.3.1.5 Algal Blooms

Conclusion a: A significant water quality concern consistently cited by all SBA contractors is the taste and odor problem and the production by algae of the offensive taste and odor compounds, MIB and geosmin. Taste and odor problems in the SBA result from a combination of algal production in Delta source waters and in the open portions of the SBA. Algae continue to grow in the SBA open canal during favorable growth conditions that generally occur during the warmer months.

Algal blooms in the SBA have historically been treated with copper sulfate. Beginning in 2000, DWR began adding a lower concentration of copper sulfate earlier in the season to better control algal blooms. SBA water treatment plants reported an improvement in taste and odor problems.

> **Recommendation:** DWR should continue the current copper sulfate regime for several years and the high-frequency closed loop stripping analysis (CLSA) with rapid feedback to SBA contractors to determine appropriate water delivery and WTP operations when taste and odor values exceed thresholds.

> **Recommendation:** DWR should continue to evaluate algal presence and species to determine relative contributions to taste and odor problems and if there also are ancillary benefits from copper sulfate treatments. DWR should also continue to evaluate the results of CLSA studies and coordinate this and recommended studies with related activities at Lake Del Valle.

5.3.1.6 Agricultural Activities

Conclusion a: There is a substantial amount of agriculture in the vicinity of the SBA, including vineyards, but the majority is out of the immediate drainage area of the SBA, farther west and north. Although contractors reported vineyards as an agricultural land use of potential concern along the SBA and the number of vineyards were reported to be increasing, the vineyards appear to be a minor threat to water quality at this time.

5.3.2 LAKE DEL VALLE

5.3.2.1 Recreation

Conclusion a: Recreation usage figures from 1996 to 1999 indicate a general decline from 1995 and previous years. The availability and quality of recreation activities and services at Lake Del Valle are highly affected by lake water levels, with the most favorable lake level at about 703 feet.

Conclusion b: Recreation activities at Lake Del Valle present a moderate threat to water quality. Body contact recreation and boating are potential sources of the microbial pathogens *Giardia* and *Cryptosporidium* in the lake. Pathogen issues at Lake Del Valle and the SBA are addressed in Chapter 12.

Conclusion c: Boating is a major recreational activity at Lake Del Valle. The primary water quality concern associated with boating is MTBE contamination from motorized watercraft. Most boating activity occurs from May to October.

> **Recommendation:** Support implementation and enforcement of new regulations for changed engine design. Evaluate and support use of alternative fuels without MTBE (for example, as with some Santa Clara Valley Water District reservoirs), especially in rental boats at the concessionaire. Encourage owners of older boats using Lake Del Valle to replace 2-stroke engines with direct injection engines or 4-stroke engines.

> **Recommendation:** DWR should continue and/or increase regular MTBE monitoring and event sampling around peak holidays. Conduct monitoring from a boat using non-MTBE gasoline or a direct injection engine, or an electric motor. The data should be made available to all interested parties.

Conclusion d: Activities in and around campground areas, especially those near the water line, along trails, and parking areas can contribute to soil erosion and can cause increased turbidity in the lake.

> **Recommendation:** DWR and the East Bay Regional Park District (EBRPD) should evaluate conditions and implement erosion control BMPs if necessary in coordination with other responsible agencies in areas close to Arroyo Valle Creek and the lake.

5.3.2.2 Wastewater Treatment/Facilities

Conclusion a: The major water quality problem associated with wastewater facilities at Lake Del Valle is the potential contribution of microbial pathogens *Giardia* and *Cryptosporidium* from spills or overflows of raw sewage.

Conclusion b: The wastewater facilities serving the Lake Del Valle park area include full service restrooms with flush toilets located in camping areas, associated collection and pumping facilities, wastewater evaporation ponds, and 15 chemical toilets. There were no spills or problems with the chemical toilets during 1996 to 1999.

Conclusion c: On 24 May 1998 there was a sewage spill of an unknown amount from a septic line lift station into the Lang Canyon stream inlet to Lake Del Valle. EBRPD staff reported that the spill was stopped and booms were installed around the area of the spill. The west branch of the reservoir was closed until tests determined there was no contamination.

Conclusion d: Except for the spill described in Conclusion c, all systems within the area were reported to have operated properly within the report period. However, the potential for spills or system failures to contribute pathogens, organic carbon, and nutrients to the lake poses a moderate threat to water quality.

> **Recommendation:** DWR should coordinate with the EBRPD to evaluate the need for upgraded and/or expanded prevention and back-up systems for wastewater facilities determined to have the highest potential risk because of their proximity to the lake or streams.

> **Recommendation:** DWR, EBRPD, and other applicable public health agencies should review emergency response procedures for septic and sewage system spills and upgrade as necessary.

5.3.2.3 Urban Runoff

Conclusion a: Runoff from urban areas in the watershed to the lake is minimal because of the low level of development and results primarily from parking lots and roads in the recreation areas. While these various sources of runoff can be a source of turbidity, pathogens, and nutrients, the threat to water quality is considered minimal.

5.3.2.4 Animal Populations

Conclusion a: The Del Valle watershed has a long history of extensive cattle grazing operations both around the edge of the lake and the dam area and in the upper watershed. Cattle have historically had access to the lake, but not typically from June through October when grass is scarce. There is some fencing present, mostly around recreation areas, but much of the grazed lands are unfenced to the lake.

Conclusion b: Grazing as a land use practice is being evaluated by EBRPD on all park lands. Installation of fencing to keep cattle from reaching the lake is limited because of the high cost.

> **Recommendation:** DWR should coordinate with EBRPD to obtain funding sources for additional fencing in critical areas.

Conclusion c: Although grazing occurs in the SBA/Lake Del Valle watershed, water is not normally drawn from the reservoir until late summer/fall. Flushing of contaminants from the watershed into the lake occurs in the winter. This may explain the relatively low fecal and *E. coli* bacteria counts observed at water treatment plants when Lake Del Valle water was utilized (see Chapter 12 for pathogens issues).

Conclusion d: A substantial wild animal population is present, but because of the extensive undeveloped and rugged nature of the watershed, little is known of actual numbers of animals and their condition. Droppings from these animals are a potential source of pathogens in the watershed and have been identified by contractors as a water quality concern.

> **Recommendation:** If future operational scenarios envision use of Del Valle water earlier in the year, a watershed assessment study should be conducted to characterize seasonal pathogen contamination. See "General Conclusions and Recommendations" at the start of this section on Chapter 5.

5.3.2.5 Algal Blooms

Conclusion a: Nuisance algal growth has been a historical occurrence at Lake Del Valle and presents a moderate threat to water quality. The primary adverse effects on water quality associated with algal blooms are increased turbidity, which affects plant operations, and taste and odor resulting from production of 2 organic compounds, MIB and geosmin.

Conclusion b: Algal blooms at Lake Del Valle and other SWP reservoirs result from a complex interaction of nutrient loading (nitrogen and phosphorus), mixing processes, and species interactions and are hard to predict. However, the level of algal growth in Lake Del Valle is lower than in Southern California SWP reservoirs.

Conclusion c: A primary cause of algal blooms at Lake Del Valle is the nutrient loads from the Sacramento-San Joaquin Delta. Local nutrient sources within the lake watershed (animal populations, sewage spills, internal lake recycling) may also be causes of algal blooms. However, the relative contribution of SBA/Delta source waters and watershed sources to the observed reservoir algal blooms is not known.

Conclusion d: Chemical controls for algal growths have never been used in Lake Del Valle.

> **Recommendation:** DWR should support taste and odor monitoring efforts to evaluate algal presence and species to determine relative contributions to taste and odor problems, including times when SBA water is delivered to Lake Del Valle. Taste and odor monitoring efforts should be coordinated with the general watershed assessment study recommended in this section.

5.3.2.6 Agricultural Activities

Conclusion a: The primary agricultural activity in the watershed is livestock production. Because of the location and type of terrain prevalent in the watershed, other types of agricultural development are extremely limited. There are no herbicides or pesticides used in the lake. The herbicide Roundup® is used. Surflan® is also used in the watershed for control of terrestrial weeds on roads and camping areas away from the lake shore. This potential contaminant source presents minimal threat to water quality.

5.3.2.12 Land Use Changes

Conclusion a: The lake and watershed area is highly erosive during rains. About 80% of the land in the Lake Del Valle drainage basin is classified as a severe erosion hazard because of its shallow soils and steep slopes. Because of these conditions, the Lake

Del Valle watershed is extremely sensitive to land use changes such as urbanization and development.

Conclusion b: Arroyo Valle Creek has deposited some 20,000 cubic yards of silt in the reservoir since the dam was built. The sediment load from the creek can cause elevated turbidities in the lake.

Conclusion c: Even limited land use changes such as construction of access roads or grading for construction, if not carefully planned, could accelerate soil erosion and/or landslide problems. Because of this the watershed is very vulnerable, and there is a substantial potential threat to water quality if significant land use changes were to occur in the basin.

> **Recommendation:** Establish a watershed coordinator position to monitor land use changes and to work with landowners and agencies to encourage planning and land use practices that protect water quality. See "General Conclusions and Recommendations" at the start of this section on Chapter 5.

CHAPTER 6 SAN LUIS RESERVOIR

6.3.1 RECREATION

Conclusion a: Body contact recreation and boating in the reservoir are potential sources of microbial pathogens and bacteria. In addition to wind, motorized boats increase wave action on the shoreline and increase turbidity. Motorized boats did not appear to contribute significant MTBE. The highest turbidity occurred in the summer months during the survey period. Ammonia, low levels of total and fecal Coliform, and *E. Coli* were detected frequently at the Pacheco Intake that supplies source water to the Santa Clara Valley Water District (SCVWD) for treatment.

> **Recommendation**: DWR in collaboration with the California State Parks should seek to improve public awareness of water quality and provide more restrooms around the reservoir. If future recreational use increases, DWR should investigate the need to restrict swimming and reduce the number and speed of boats.

Conclusion b: Use of the watershed by visitors was moderate during the survey period compared with visitation at the Southern California reservoirs. Runoff from campgrounds, parking grounds, the Pacheco State Park, and boat ramps contributes contaminants such as turbidity and TOC to the reservoir, particularly during the winter and spring months.

> **Recommendation:** The number of visitors to the watershed will likely increase because of lowered use fees that were recently enacted. DWR should consider conduct studies to estimate total runoff in the watershed and quantify contaminants that enter the reservoir.

6.3.2 WASTEWATER TREATMENT/FACILITIES

Conclusion a: There are no wastewater treatment plants or effluent discharges to the reservoir. Existing wastewater evaporation ponds and toilets are designed to prevent discharges to the lake and have evidently been successful.

6.3.3 ANIMAL POPULATIONS

Conclusion a: No dairy farms are close to the reservoir. Seasonal animal grazing, wild animals, and large numbers of migrating waterfowl are considered significant contributors of turbidity, nutrients, TOC, and pathogens. Animals were found in direct contact with water in the reservoir. The number of seasonal grazing animals and the species and number of wild animals are not known. Pathogens and ammonia were detected frequently in water at the SCVWD Pacheco Intake.

> **Recommendation:** DWR should build fences in areas as needed on the periphery of the reservoir to confine grazing animals and wildlife to eliminate pathogen exposure from this source. Alternative water supplies for animals should also be considered.

> **Recommendation:** DWR should study the effects of animal populations on water contamination in the reservoir, particularly contributions of TOC, nutrients, turbidity, and pathogens by grazing, wild animals, and waterfowl.

> **Recommendation:** DWR needs to review existing grazing leases to ensure the watershed is protected.

> **Recommendation:** DWR should investigate possible ways to divert runoff immediately downstream from the 2 wildlife areas away from the reservoir.

6.3.4 ALGAL BLOOMS

Conclusion a: The SWP source water for San Luis Reservoir contains high concentrations of nutrients (nitrogen and phosphorus) that can support significant algal growth (see discussion on SWP nutrients in Chapter 7). Other factors in San Luis Reservoir such as temperature, disturbance, and light penetration often limit algal formation. Algal growth was a problem during the drought years from 1992 to 1993, but algal blooms did not produce taste and odor problems during 1996 to 1999.

> **Recommendation:** DWR needs to review existing flavor profile data of the SCVWD and investigate the need to control algae during drought years or other times when blooms occur.

6.3.5 AGRICULTURAL ACTIVITIES

Conclusion a: Very little irrigated crop production occurs in the watershed. Pesticides are used for weed control, but no off-site movement of pesticides was observed. No significant agricultural runoff drained to the reservoir.

6.3.6 TRAFFIC ACCIDENTS/SPILLS

Conclusion a: Highway 152 is a major transportation corridor in the area. A section of Highway 152 (approximately 10 miles) runs adjacent to and across the reservoir and watershed. A Caltrans fence is on either side of the highway. Spills of hazardous chemicals are possible, but no serious accidents or spills occurred during the survey period.

> **Recommendation:** DWR, in collaboration with other agencies, should identify and assess emergency action plans and procedures for possible hazardous spills along Highway 152. Responsible agencies should also evaluate training and education needs to ensure a coordinated and prompt response to an emergency.

6.3.8 FIRES

Conclusion a: Fires occurred in the reservoir watershed during the survey period and likely contributed turbidity, TOC, and TDS to the reservoir.

> **Recommendation:** Evaluate the existence and appropriate level of public education on fire dangers, including warning signs and billboards.

DELTA SOURCE WATER QUALITY

Conclusion a: Seawater intrusion influenced to the reservoir through the source water from both the State and federal water projects. Bromide concentrations in the reservoir were comparable to those at the Banks Pumping Plant and DMC during the survey period. Source water from DMC and the California Aqueduct can be a contributor of TOC, turbidity, and TDS in the reservoir because these constituents are generally higher during the winter and spring months when water is pumped into the reservoir.

> **Recommendation:** DWR should determine the relative contributions of TOC, turbidity, and bromide from the California Aqueduct, the DMC, and the reservoir's natural watershed and investigate operational scenarios to minimize concentrations of these constituents in the reservoir consistent with maintaining reliable water supply.

> **Recommendation:** DWR should study the effects of algal blooms on TOC in the reservoir.

CHAPTER 7 SOUTHERN CALIFORNIA RESERVOIRS

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: Although water quality at all 4 reservoirs is an important concern, the water quality at Castaic and Silverwood lakes is of particular concern because these lakes are the supply points for the majority of the SWP Southern California supply via Jensen and Mills filtration plants (FPs) and the Castaic Lake Water Agency.

Conclusion b: Recreational boating is a known source of MTBE and hydrocarbons in all SWP reservoirs where motorized watercraft are allowed. The following recommendations apply to the 4 reservoirs addressed in this chapter.

> **Recommendation:** Support implementation and enforcement of new regulations for changed engine design. Evaluate the feasibility of requiring boaters using the reservoirs to use alternative fuels without MTBE. Encourage

owners of older boats using the reservoirs to replace 2-stroke engines with direct injection engines or 4-stroke engines.

Recommendation: Support CARB efforts to create a buy-back program to remove pre-2001 model year marine engines from use. Coordinate and cooperate with the CARB and marine engine manufacturers on this issue.

Recommendation: DWR and the Metropolitan Water District of Southern California (MWDSC) should continue and/or increase regular hydrocarbon and MTBE monitoring and event sampling around peak holidays. Monitoring should be conducted from a boat using non-MTBE gasoline, a direct injection engine, or an electric motor. The data should be made available to all interested parties.

Conclusion c: There are several contaminant sources and related water quality problems (for example, grazing, recreation, pathogens, MTBE, algae, taste and odor) that are common to the 4 reservoirs. Their analysis would greatly benefit from an integrated watershed management program approach. Relative to the other Southern California reservoirs, water quality problems in Pyramid Lake are minor in terms of potential impacts associated with common major contaminant sources such as recreation, wastewater facilities, and grazing.

Recommendation: A WMP should be initiated at Castaic and Silverwood lakes and Lake Perris to coordinate existing and future watershed management activities and studies. DWR should support this effort by creating a watershed coordinator position. Personnel heading the WMP should act as contacts for information on all watershed management practices and provide a clearinghouse of watershed information (recreational use, cattle grazing, sewage system operation, etc.).

Recommendation: A comprehensive study in coordination with MWDSC should be made of the major sources of nutrients to Castaic Lake and the other Southern California reservoirs. This study should be coordinated with other recommendations made in the individual reservoir sections and be integrated with the current reservoir water quality management program by DWR's Southern Field Division and MWDSC. The study should address algal dynamics and nutrient cycling within the major reservoirs to better understand the processes controlling algal populations. Study findings should provide information for early warning of algal blooms and offer recommendations on more effective and lower cost control measures, including pre-emptive treatment or reduction in local nutrient sources. These activities should be coordinated with and adapted to construction projects or other activities potentially causing erosion and increased turbidity.

Recommendation: Because of the complex and dynamic nature of potential contaminant sources in the Southern California SWP reservoirs, consideration should be given to constructing a Geographic Information System (GIS) as part of the WMP to provide state and local agencies with information required for effective management of the lake and watershed.

7.1 PYRAMID LAKE

General Conclusions and recommendations

Conclusion a: Natural sources in Piru Creek contribute high loadings of TDS and sulfate, which are then transferred to Castaic Lake. However, the impact of these constituents on drinking water supplies taken from the West Branch of the California Aqueduct appears to be modest.

Recommendation: Monitor loads of these constituents in Piru Creek and Pyramid Lake, including measuring Piru Creek flows.

7.1.3.1 Recreation

Conclusion a: Recreation activities at Pyramid Lake can contribute pathogens from boating, floating and chemical toilets, and body contact activity. No data were available to determine the level of contamination from any of these sources.

Recommendation: Review programs of responsible agencies such as the US Forest Service, DWR, or their contracted concessionaires to evaluate both floating and land chemical toilet use, location, and management. Evaluate stability and design for better control of tipping and spillage. Review the adequacy of contingency plans for spill prevention and abatement.

Recommendation: Review the programs of responsible agencies such as the US Forest Service, DWR, or their contracted concessionaires to evaluate boating pump-out facilities and install or upgrade if necessary. Educate boaters about the problem and encourage use of pump-out facilities or on-shore and off-shore restrooms.

Conclusion b: Activities in and around campground areas, especially those near the water line, and Hungry Valley State Recreation Area (SRA) off-highway vehicle (OHV) use contribute to erosion and can cause increased turbidity in the lake.

Recommendation: Implement erosion control BMPs, in coordination with the US Forest Service and other responsible agencies in areas close to the creek or lake. Evaluate activities and recreation use in the Hungry Valley SRA and implement specific BMPs in that area if warranted.

7.1.3.3 Animal Populations

Conclusion a: Cattle grazing has occurred historically in the watershed and also during the report period; however, the current status is unknown. Data on the numbers and specific grazing areas were not available. The large watershed also contains a significant wild animal population. Wastes from these animal populations can be flushed into the lake and are a potentially significant source of pathogens.

Recommendation: DWR and the US Forest Service should evaluate grazing allotments, locations, proximity to water, and identify areas near water or where high erosion potential exists that are sensitive to grazing activities. Grazing allotments should be modified accordingly. Evaluate adequacy of fencing in grazing areas. Detailed data should be collected on past and future grazing activities in order to assess the need for additional fencing around Pyramid Lake. Better coordination among governing agencies is needed.

Recommendation: Re-evaluate the range management policies of DWR and US Forest Service using updated grazing data and water quality information to determine the carrying capacity of the watershed with respect to water quality protection.

7.1.3.4 Crude Oil Pipelines and 7.1.3.8 Traffic Accidents/Spills

Conclusion a: A fuel spill incident from a truck occurred on I-5 and drained into Gorman Creek. The spill was contained and cleaned up by a nearby HAZMAT crew. No incidents were reported for crude oil pipelines. There is potential for ruptures of crude oil pipelines in the vicinity of the lake and hazardous materials spills from I-5 to reach the lake. Overall accidents and spills pose a moderate threat to water quality in Pyramid Lake.

Recommendation: Identify and assess emergency action plans and procedures relating to these potential sources of contamination. Review training and education and coordination with responsible and interested agencies to ensure effective emergency response.

Recommendation: DWR should review emergency spill procedures to determine if they are adequate for future population and traffic growth in the area and update these procedures as needed.

7.1.3.7 Unauthorized Activity

Conclusion a: One leaking underground storage tank was reported in 1992. It was removed, and remediation was begun. This site is reportedly still being monitored quarterly, but it is not known if there are any effects on lake water quality.

Recommendation: DWR should determine the status of the remediation with the Regional Water Quality Control Board and county health department to ensure that there is no threat to water quality.

7.1.3.9 Geologic Hazards

Conclusion a: Three major faults and several smaller faults in the watershed make the area susceptible to pipeline ruptures (such as crude oil) because of seismic activity. This is considered a moderate potential threat to water quality.

7.2 CASTAIC LAKE

7.2.3.1 Recreation

Conclusion a: Recreation activities in Castaic Lake present a moderate threat to water quality. Body contact recreation and use of PWC and boats are sources of pathogens and MTBE in the lake. Pathogen issues at Castaic Lake are addressed in Chapter 12. Erosion associated with hiking, horseback riding, or camping, particularly if activities are conducted off established trails and areas, can be a source of turbidity.

Conclusion b: Surface MTBE values in Castaic Lake routinely exceed the primary MCL of 13 µg/L during the summer months when recreational use is highest. Highest concentrations were found near the boat ramps and outlet to the lake; PWC users are confined to an area near the outlet of the lake. Deep waters in the lake appear to have low or undetectable levels of MTBE even during summer months.

In addition to the previous general recommendations for MTBE contamination, the following are specific recommendations for Castaic Lake:

> **Recommendation:** No fueling of PWC or boat engines using portable gas cans should be allowed on the lake or in the vicinity of the boat ramps.
>
> **Recommendation:** Because MTBE levels are directly related to recreational activities, PWC areas should be moved away from the outlet of the lake, thereby providing for more dilution of the contaminant before it reaches the outlet.

7.2.3.2 Wastewater Treatment/Facilities

Conclusion a: There are a number of sewage lift stations and small septic systems in the Castaic Lake watershed operated by DWR, the Los Angeles Department of Water and Power (LADWP), and private parties. These systems can contribute to pathogen contamination in the lake and represent a moderate threat to water quality. Limited data were available on the number, location, and condition of septic systems in the Castaic Lake watershed.

Conclusion b: A sewage spill occurred at the Elderberry Forebay (Castaic Powerplant) from a septic system in 1996. Problems with septic systems in the Elizabeth Lakes complex were reported in the 1970s, which is in the northeastern-most portion of the watershed and drains to Elizabeth Lake Canyon Creek.

> **Recommendation:** Emergency response procedures for septic and sewage system spills should be reviewed by DWR, LADWP, and applicable public health agencies and upgraded as necessary.
>
> **Recommendation:** Secondary containment and spill alarms should be installed at all sewage lift stations operated by LADWP.
>
> **Recommendation:** An evaluation of existing septic systems and sewage lines and their potential risk to water quality should be conducted in coordination with the aforementioned WMP under General Conclusions and Recommendations for Southern California Reservoirs. These data should be made readily available to State and local agencies.

7.2.3.4 Animal Populations

Conclusion a: Grazing of livestock (cattle and sheep) occurs in the Castaic Lake watershed and presents a significant threat to water quality because of the potential contribution of pathogens. Both cattle and sheep have been observed grazing to the edge of Castaic Lake, and cattle have been observed grazing in the Elderberry Forebay since a 1996 fire destroyed the fencing.

Conclusion b: There is concern that grazing management practices in the Castaic watershed may contribute to nutrient and pathogen contamination in the reservoir.

Conclusion c: Grazing is under the management of multiple agencies, including DWR and the US Forest Service.

> **Recommendation:** DWR and property owners should hold discussions to ensure that preventive measures are in place to reduce the risk of contamination, including possibly replacing the fence around Elderberry Forebay. See also General Conclusions and Recommendations for Southern California Reservoirs regarding watershed assessment studies and coordination.
>
> **Recommendation:** Pathogens issues at Castaic Lake are discussed in Chapter 12. See General Conclusions and Recommendations

for Southern California Reservoirs regarding watershed assessment studies and coordination. Consider studies to identify potential contribution from wild animal populations versus grazing animals.

Recommendation: DWR and the US Forest Service should evaluate grazing allotments, locations and proximity to water and identify sensitive areas to avoid grazing such as the Elderberry Forebay, around the lake, or where high erosion potential exists. Grazing allotments should be modified accordingly. Evaluate the adequacy of fencing in sensitive grazing areas. Detailed data should be collected on past and future grazing activities in order to assess the need for additional fencing around Castaic Lake. No comprehensive database exists on numbers and types of animals grazed and areas where grazing is allowed. Better coordination between governing agencies is needed.

Recommendation: Re-evaluate the range management policies of DWR and US Forest Service using updated grazing data and water quality information to determine the optimal carrying capacity of the watershed.

7.2.3.5 Algal Blooms

Conclusion a: Nuisance algal growth has been a historical occurrence at Castaic Lake and presents a moderate threat to water quality. Algal blooms can produce water quality conditions that disrupt water treatment plants. The primary adverse effects on water quality associated with algal blooms are increased turbidity, which clogs treatment plant filters, disruption of filters causing turbidity breakthrough, and taste and odor resulting from production of the taste and odor causing compounds, MIB and geosmin.

Conclusion b: The Jensen FP experienced a dramatic change in raw water quality from Castaic Lake that disrupted plant operation, resulting in higher than normal effluent turbidities. The Castaic Lake Water Agency elected to shut down its treatment plant because of treatment difficulties caused by algal blooms. Treatment of Castaic Lake has been necessary to control algal populations, increasing costs to the SWP.

Conclusion c: Algal blooms at Castaic and other SWP facilities result from a complex interaction of nutrient loading (nitrogen and phosphorus), mixing processes and species interactions that are hard to predict.

Conclusion d: A primary cause of algal blooms at Castaic and in the SWP is high nutrient loads from the Sacramento-San Joaquin Delta. Local nutrient sources within the Castaic Lake watershed (animal populations, sewage spills, internal lake recycling) may also be significant causes of algal blooms, but data are lacking to judge their significance.

Recommendation: Refer to the Southern California Reservoirs General Conclusions and Recommendations for a discussion of the comprehensive watershed study for early warning and control of algal blooms and other contaminant sources.

7.2.3.9 Traffic Accidents/Spills

Conclusion a: Hydraulic pump oil leaks from SWP facility operations can be a common occurrence. On 12 November 1996, 19 gallons of hydraulic oil leaked from the Castaic Intake Tower. This is considered a moderate potential threat to water quality.

7.2.3.12 Fires

Conclusion a: Large wildfires have occurred in the Castaic Lake watershed and have resulted in sediment loading to the lake. Sediment loading can increase the TDS and turbidity of the lake resulting in the need for additional treatment. Ash may also represent a large nutrient input and could stimulate algal blooms. Overall, wildfires represent a moderate threat to water quality in Castaic Lake.

7.3 SILVERWOOD LAKE

7.3.3.1 Recreation

Conclusion a: The most significant potential contaminant source at Silverwood Lake associated with watershed activities is recreation.

Conclusion b: Recreation activities such as body contact sports, boating, and restroom facilities may contribute pathogens. Body contact recreation is probably the most significant, although unquantified, potential pathogen source, followed by spills from restroom facilities. One incident occurred where a floating toilet capsized about a mile from the lake outlet. Pathogen issues at Castaic Lake are addressed in Chapter 12.

Recommendation: The stability of the floating restroom should be evaluated and measures should be taken to prevent capsizing and spills, if possible. Rapid clean-up response procedures should also be evaluated and implemented, if necessary.

Conclusion c: MTBE is released from motorized watercraft and is routinely detected throughout the reservoir. MTBE levels in Silverwood Lake did not exceed the primary MCL of 13 µg/L but routinely exceeds the secondary MCL of 5 µg/L even deep in the reservoir. This is of concern because sensitive members of the population could taste MTBE at the levels that occur in the reservoir. Deep water in the lake appears to have low or undetectable levels of MTBE even during summer months.

In addition to the recommendations for MTBE contamination presented under General Conclusions and Recommendations for Southern California Reservoirs, the following are specific recommendations for Silverwood Lake:

Recommendation: No fueling of PWC or boat engines using portable gas cans should be allowed on the lake or in the vicinity of the boat ramps.

Recommendation: Because MTBE levels are directly related to recreational activities, the feasibility of moving PWC areas away from the outlet of the lake should be evaluated. This would provide more dilution of the contaminant before it reaches the outlet.

Conclusion d: Recreation activities such as hiking, horseback riding, and off-highway vehicle use may cause erosion and contribute to increased turbidity in the lake.

Recommendation: Implement education and coordination outreach program to educate all users. Evaluate implementation of BMPs and other erosion control measures. For example, the US Forest Service is working with OHV user groups to minimize erosion caused by OHV use.

7.3.3.2 Wastewater Treatment/Facilities

Conclusion a: There are 4 wastewater treatment plants and their associated collection and pumping facilities in the Silverwood Lake watershed. Some of these facilities are close to the lake and/or tributary streams. All systems within the area were reported to have operated properly within the report period; however, the potential for spills or system failures to contribute pathogens, organic carbon, and nutrients to the lake is significant.

Recommendation: Evaluate the need to upgrade and/or expand prevention and back-up systems for wastewater treatment plants determined to have the highest potential risk because of their proximity to the lake or streams. For example, the Crestline Sanitation District improved its emergency overflow storage facilities. Also evaluate facilities in the Lake Gregory area.

7.3.3.4 Animal Populations

Conclusion a: Grazing has occurred but did not appear to be a significant activity during the report period; however, there is a substantial but unquantified wild animal population in the watershed. Animal populations are considered a moderate potential source of nutrients and pathogens.

Recommendation: Pathogens issues at Silverwood Lake are discussed in Chapter 12. See General Conclusions and Recommendations for Southern California Reservoirs regarding related watershed assessment studies and the watershed coordinator position. Consider studies to identify potential contribution from wild animal populations versus grazing animals.

7.3.3.5 Algal Blooms

Conclusion a: Excessive algal blooms result in increased turbidity and increased production of MIB and geosmin in Silverwood Lake. However, residence time is generally too short for algal biomass to increase to problematic levels. Treatment of algal blooms with copper sulfate has only been necessary on rare occasions when the East Branch of the California Aqueduct was shutdown for an extended period. Algal growth is also a problem in Lake Gregory, which drains to Silverwood Lake at certain times of the year. Algal blooms can produce water quality conditions that disrupt water treatment

processes. The primary adverse effects on water quality associated with algal blooms are increased turbidity, which affects plant operations, and taste and odor resulting from production of MIB and geosmin.

Conclusion b: Algal blooms at Silverwood Lake and other SWP facilities result from a complex interaction of nutrient loading (nitrogen and phosphorus), mixing processes, and species interactions that are hard to predict.

Conclusion c: A primary cause of algal blooms at Silverwood and in the SWP is the high nutrient loads from the Sacramento/San Joaquin Delta. As a result of the short residence time of water in Silverwood Lake, nutrients from the local watershed (for example, animal populations, sewage spills) will only become important if the nutrient loading from the Sacramento/San Joaquin Delta is greatly reduced.

> **Recommendation:** Refer to General Conclusions and Recommendations for Southern California Reservoirs for a discussion of the comprehensive watershed study for early warning and control of algal blooms and other contaminant sources.

7.3.3.9 Land Use Changes

Conclusion a: Both the San Bernardino Tunnel Reconstruction Project and the Crestline/Lake Arrowhead Water Agency Tank Reconstruction Project contributed to soil erosion and increased turbidity in Silverwood Lake and diversions from Devil Canyon.

> **Recommendation:** Regulatory agencies, for example, the Regional Water Quality Control Board, responsible for storm water runoff from construction or other activities with potential to increase erosion should review construction mitigation measures and ensure they are properly implemented.

7.4 LAKE PERRIS

General Conclusions and Recommendations

Conclusion a: Lake Perris has unique problems caused by a combination of several factors. The reservoir strongly stratifies with a shallow epilimnion. The hypolimnion has a very high oxygen demand caused by decomposition of settling algae in the sediments. This results in 30% to 40% of the water column becoming unusable because of hypolimnetic anoxia during the summer months when water demands are the highest. There have been long periods when withdrawals from Lake Perris were minimized. During these periods, evaporation has concentrated dissolved solids, increasing TDS.

7.4.3.1 Recreation

Conclusion a: Lake Perris has the highest numbers of recreational visitors of all the SWP reservoirs addressed in this sanitary survey. The heavy recreational use, especially body contact recreation, leads to high levels of pathogens. This has resulted in several beach closures during the past 2 decades.

> **Recommendation:** DWR, the California State Parks, local governments, and representatives of water utilities formed an SWP Recreation and Water Quality focus group that meets regularly to discuss recreation in conjunction with water quality improvement. This group should review the recommendations of *Sanitary Survey Update 2001* and implement them at Lake Perris as appropriate.

> **Recommendation:** Re-evaluate and aggressively implement sanitation education programs and increase the availability of restroom facilities near swimming beaches.

> **Recommendation:** Install baby changing stations in restrooms near the swimming beaches to encourage hygienic disposal of infant waste.

Conclusion b: Large circulation pumps were installed at the 2 swimming beaches in an attempt to reduce pathogen levels at the beaches. These pumps may have the effect of moving the pathogens toward the lake outlet, which could have a negative effect on the drinking water supply to MWDSC.

> **Recommendation:** A tracer study should be conducted to determine the effectiveness of the pumps and to insure that they will not circulate pathogens toward the lake outlet.

Conclusion c: Because of high levels of recreational boating, Lake Perris has the highest MTBE levels of any SWP reservoir.

In addition to the General Conclusions and Recommendations for Southern California Reservoirs regarding MTBE contamination, specific recommendations for Lake Perris follow:

> **Recommendation:** Re-evaluate limits on the number of motorized watercraft allowed at Lake Perris to avoid excessive concentrations of MTBE. One objective should be to avoid exceeding the secondary MCL for MTBE.
>
> **Recommendation:** Discourage PWC use at Lake Perris to reduce levels of MTBE and hydrocarbons.

7.4.3.2 Wastewater Treatment/Facilities

Conclusion a: Wastewater collection and conveyance facilities present a considerable potential to fail and contaminate the lake. Sewage lift stations at Lake Perris overflowed on 2 occasions during the period of this study. Both lift stations were near the lakeshore and contaminated the reservoir with untreated sewage.

> **Recommendation:** Conduct a thorough evaluation of the condition of sewage collection facilities at Lake Perris. Install secondary containment and warning alarms wherever applicable.

7.4.3.5 Unauthorized Activity

Conclusion a: An underground storage tank near the marina failed in 1994, contaminating groundwater adjacent to the lake. Remediation has been hampered by high groundwater elevation in the area, which is directly related to the lake surface elevation.

> **Recommendation:** Draw down the reservoir for a sufficient period to remediate contaminated groundwater in the area that could affect the water quality of Lake Perris.

CHAPTER 8 CALIFORNIA AQUEDUCT

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: Water quality in the California Aqueduct is largely determined by conditions in the Sacramento/San Joaquin Delta Estuary. Floodwater inflows from the Diablo Range are a significant PCS in the San Luis Canal. Inflows from the Kern River Intertie (KRI) and Cross Valley Canal (CVC) generally improved the mineral quality of aqueduct water with low salinity runoff from the Sierra Nevada but can contribute significant sediment loads to the California Aqueduct.

8.1 CLIFTON COURT FOREBAY TO O'NEILL FOREBAY

8.1.3.1 Recreation

Conclusion a: Recreational use of Clifton Court Forebay is light relative to other SWP reservoirs and is confined to shore fishing and duck hunting. Since motorized watercraft and swimming are prohibited, recreation poses minimal threat to water quality in the California Aqueduct.

8.1.3.4 Animal Populations

Conclusion a: No livestock grazing takes place in the watershed to Clifton Court, and wildlife populations within the basin pose little threat to water quality in the California Aqueduct.

8.1.3.8 Traffic Accidents and Spills

Conclusion a: In 1997, a small portion of liner slumped into the aqueduct at milepost 62. Oil was released from soil under the liner that contained residual from a pipeline break in 1984. Aromatic hydrocarbons (such as benzene and toluene) were detected in the aqueduct for several days thereafter. The exposed soil was covered to prevent further oil seepage, and absorbent booms were placed in the aqueduct to ensure containment.

Conclusion b: Liner repair at this site has been delayed because any activity could release oil to the aqueduct. DWR has requested that the CVRWQCB have the site remediated by the pipeline owner so that repairs can be made.

8.1.3.9 Groundwater Discharges

Conclusion a: Groundwater is pumped into the aqueduct along the west bank to reduce the pressure of shallow groundwater on the aqueduct. Some of these groundwaters have high salinity. Groundwater pump-ins in this section have historically been small relative to the other sections of the California Aqueduct and pose a minor threat to water quality.

8.1.3.11 Geologic Hazards

Conclusion a: The south levee of Clifton Court Forebay lies parallel to the Vernalis geologic fault, and the local groundwater is relatively saline. There is no indication of increased salinity in Clifton Court because of these groundwater inputs, and this source appears to pose a minor risk to water quality in the California Aqueduct.

> **Recommendation:** Because geologic faults are dynamic, groundwater conditions could change in the future, thus water quality data should continue to be collected and evaluated.

8.2 THE O'NEILL FOREBAY

8.2.3.1 The Delta Mendota Canal

Conclusion a: DMC water can be pumped into O'Neill Forebay by the O'Neill Pumping-Generating plant at mile 69.25 on the DMC. DMC inputs can significantly influence water quality in the SWP. During 1995 to 1997, the DMC accounted for 21% to 37% of the inflow to O'Neill Forebay but contributed 33% to 55% of the TDS load and 37% to 59% of the nitrate load. In 1995, DMC inflows made up 49% and 56% of the load of TOC and bromide, respectively, to the O'Neill Forebay.

Conclusion b: A number of studies have concluded that DMC water has a different composition than California Aqueduct diversions, largely due to greater influence from the San Joaquin River. The DMC generally has higher salinity than the California Aqueduct upstream of O'Neill Forebay.

Conclusion c: Salinity has become an important issue for SWP contractors in Southern California who blend higher-salinity Colorado River water with aqueduct water to improve drinking water quality. Blending is also done to reduce the salinity of water used to replenish regional groundwater aquifers. SWP salinity is variable, partly because of fluctuating DMC inputs, which complicate blending practices. In the future, more operational flexibility may be required at O'Neill Forebay to respond to variable water quality conditions.

> **Recommendation:** The capability to forecast salinity and identify joint-use operations (such as DMC pumping) that could reduce the salinity of SWP water without increasing other constituents of concern should be developed.

8.2.3.2 Recreation

Conclusion a: Contact and noncontact recreation in O'Neill Forebay includes camping, picnicking, sailboating and powerboating, waterskiing, windsurfing, fishing, swimming, and bicycling.

Conclusion b: Routine monitoring at the forebay's outlet shows that MTBE is infrequently detected. Fecal coliform bacteria are routinely detected in the north and south swim beaches during low-use periods. No data exist for high-use periods. Entrance and boat launching fees were recently reduced and may result in increased recreational use.

> **Recommendation:** MTBE and pathogen monitoring data should continue to be collected in the O'Neill Forebay.

8.2.3.5 Animal Populations

Conclusion a: The southern portion of the O'Neill watershed is used for cattle grazing between November and May. An electric fence separates the animals from the forebay's shoreline. Overall, animal populations in the basin pose only a minor threat to water quality in the forebay because catchment runoff is low due to sparse rainfall.

8.3 OUTLET OF O'NEILL FOREBAY TO CHECK 21 (KETTLEMAN CITY): SAN LUIS CANAL

Conclusion a: The San Luis Canal was built with drain inlets that convey rainfall runoff from the Diablo Range into the aqueduct. This segment of the California Aqueduct begins on the southeast edge of O'Neill Forebay and extends about 101.5 miles southeasterly to a point near Kettleman City. These floodwater inflows are the largest local contaminant source to the San Luis Canal.

8.3.3.1 Floodwater Inflows

Conclusion a: Floodwater inflows are usually high in suspended and dissolved solids. The dissolved solids, or salts, come from naturally occurring marine sediments in the Diablo Range. Suspended solids come from streambed erosion during runoff events. Floodwater inflows are significant contributors of these 2 constituents to the San Luis Canal and pose a moderate to severe threat to water quality in the California Aqueduct.

Conclusion b: Floodwater inflows can disrupt aqueduct operations and result in additional maintenance costs. Sediment inputs to the San Luis Canal can complicate drinking water treatment plant operations and increase treatment cost. Furthermore, downstream users have declined to use SWP water to recharge aquifers during periods with high floodwater inputs because high sediment loads can clog recharge ponds and injection wells. In 1998, about 21,000 acre-feet of water entered the San Luis Canal, but this gain was offset by 150,000 to 200,000 acre-feet of lost groundwater storage in Kern County.

> **Recommendation:** CALFED should support DWR and other watershed protection activities related to reducing floodwater inflows to San Luis Canal. This support could be in the form of funding and/or official endorsement of the proposed wasteway investigation. The proposal has the potential to substantially lower the potential contamination threat from floodwater inputs.

Conclusion c: Operations of drain inlet structures have been modified over the years to reduce inflow volumes and sediment loads. Studies have been ongoing since the early 1990s to address floodwater inflows from Arroyo Pasajero. The latest proposal is to convey all floodwater down the San Luis Canal to a wasteway turnout for ponding and evaporation on adjacent land. An existing interceptor drain near Dos Amigos Pumping Plant appears to act as a settling basin, removing sediments from floodwater before it enters the aqueduct.

> **Recommendation:** DWR should investigate the feasibility of incorporating interceptor drains in front of more drain inlets. The drains may provide a cost-effective means of reducing sediment discharges to the aqueduct, which constitute a significant problem for downstream SWP contractors.

Conclusion d: More data are needed to assess whether floodwater is a significant source of DBP precursors to the SWP.

> **Recommendation:** DWR should analyze organic carbon and bromide in all future floodwater inflows to the aqueduct.

8.3.3.2 Recreation

Conclusion a: There are no recreation facilities on the San Luis Canal, although several locations are popular for fishing. Noncontact recreation such as hunting and fishing is allowed in the reservoir of Little Panoche Creek Dam. Adequate toilet facilities exist at these sites, so recreational activities in the San Luis Canal reach of the aqueduct pose a minor threat to water quality.

8.3.3.5 Industrial Site Storm Water Runoff

Conclusion a: Several industries within the Arroyo Pasajero area are permitted for storm water runoff. These entities include waste management, landfills, cement production, and energy generators. Existing information suggests there is little chance of contamination of the California Aqueduct from these facilities.

8.3.3.6 Animal Populations

Conclusion a: Both range grazing and stockyards are found along the San Luis Canal section of the California Aqueduct, but in relation to the stockyards, cattle grazing is a minor PCS. Storm water runoff from the 2 confined animal operations, Harris (cattle) Ranch and Thommand Dairy, pose a significant threat of contaminating the SWP with nutrients and pathogens in the event of containment failure.

Conclusion b: At the request of DWR, Harris Ranch enlarged its ponding basins and installed headgates on the collector dams for better control of on-site runoff. The new capacity was 224 acre-feet, twice the amount of runoff expected for a 100-year, 24-hour storm. The ranch also cross-leveed and bermed land below the primary and secondary catch basins to accommodate any emergency runoff, thus providing additional protection.

> **Recommendation:** The Regional Water Quality Control Board should permit and routinely inspect 2 confined animal operations west of the San Luis Canal—Harris (cattle) Ranch and Thommand Dairy. Discharges from their holding ponds could potentially enter the aqueduct. The board should issue standing orders that codify the exclusion of this runoff.

> **Recommendation:** DWR should investigate possible ways to prevent runoff from entering the aqueduct immediately downstream of the 2 confined animal facilities. Prevention might include interceptor drains or overchutes.

8.3.3.7 Agricultural Activities

Conclusion a: Agricultural uses such as field and truck crops dominate the flatter portions of land west of the San Luis Canal. Currently used pesticides are frequently detected in low concentrations in the California Aqueduct, although it is uncertain whether these compounds are from local sources or imported from the Sacramento/San Joaquin Delta. Overspray from aerial pesticide applications made to adjacent orchards has been reported. Although agricultural activities have resulted in the introduction of pesticides to the aqueduct, pesticide MCLs were not exceeded in the SWP. Because MCLs apply to treated drinking water, concentrations measured in the source water would likely be reduced as a result of treatment.

> **Recommendation:** DWR should determine whether local or Delta sources are the dominant source of pesticides in the San Luis Canal. If canal sources are identified, control measures should be studied and implemented where feasible.

8.3.3.8 Mines

Conclusion a: There are several inactive or abandoned asbestos mines in the Arroyo Pasajero watershed along with a few active sand and gravel operations. The only other mine upstream of the San Luis Canal with a known water quality threat is the New Idria mine, an abandoned mercury mine in the upper reaches of Panoche Creek. However, runoff from the creek passes over the aqueduct via siphon, thereby preventing mine drainage from entering the aqueduct.

8.3.3.14 Geologic Hazards

Conclusion a: The geology of the Diablo Range watersheds west of the California Aqueduct contains several problematic rock types and minerals. Marine deposits contain concentrated salts such as sulfate, chloride, and magnesium. Serpentinite outcrops produce magnesium bicarbonate waters and are a source of asbestos. Highly saline springs exist in some of the watersheds that drain into the San Luis Canal during storms. The Diablo Range is the largest source of selenium in the San Joaquin Valley.

> **Recommendation:** Where feasible, runoff from Diablo Range watersheds should be prevented from entering the California Aqueduct because of water quality concerns and high sediment loads. See recommendations in Section 8.3.3.1, Floodwater Inflows.

8.4 KETTLEMAN CITY TO KERN RIVER INTERTIE

8.4.3.1 Recreation

Conclusion a: The 9 fishing sites on this section of the California Aqueduct pose a mild threat of pathogen contamination. Some of these sites lack adequate trash and toilet facilities, thus increasing the potential for contamination of the SWP with garbage and human waste.

> **Recommendation:** DWR should re-evaluate these fishing sites and ascertain whether portable toilets and garbage collection are needed to prevent contamination of drinking water supplies conveyed through the SWP.

8.4.3.3 Floodwater Inflows

Conclusion a: Water from the Kings River can be admitted to the aqueduct during storm events via Westlands Water District pumping facilities. Most of this runoff originates from the Westlands Water District inlet canal on the Mendota Pool and is composed largely of releases from Sierra Nevada dams for flood control. In typical years, no watershed runoff reaches the aqueduct in this section. There are reports of overchutes overflowing into the aqueduct during periods of high runoff. Overall, these inputs pose a minor threat to water quality in the aqueduct compared to floodwater entering the San Luis Canal.

8.4.3.4 Accidents and Spills

Conclusion a: Interstate 5 and State Highway 41 cross over the aqueduct just south of Kettleman City. State Highways 46, 58 and 119 cross over near Wasco, Buttonwillow, and Bakersfield. Two bodies and 2 automobiles were recovered from this section of the aqueduct between June 1998 and August 1999.

Conclusion b: In December 1998 the Lost Hills oil fire deposited a light film of oil over a section of the aqueduct at mile 201.5, extending downstream as far as Check 24. Clean-up efforts included oil booms in the water, which were periodically skimmed by a vacuum truck to remove the oil. The deposition of oil in the aqueduct lasted approximately 3 days. Emergency response and clean-up efforts were

sufficient to prevent major impacts on SWP water quality.

> **Recommendation:** DWR should review emergency spill procedures to determine if they are adequate to address future population, traffic, and oil-industry growth along this section of the California Aqueduct.

8.5 KERN RIVER INTERTIE TO EAST/WEST BRANCH BIFURCATION

8.5.3.1 Kern River Intertie

Conclusion a: During 1997 and 1998, the Kern River Intertie (KRI) and Cross Valley Canal (CVC) contributed a substantial amount of water to the aqueduct. KRI inflow made up most of the water delivered to Southern California during 1 month in 1997 and in almost 3 months during 1998. These floodwaters originated as Sierra Nevada runoff and were accepted into the aqueduct to protect agricultural land in the dry lakebeds of Tulare and Buena Vista.

Conclusion b: KRI and CVC inflows are of high quality with low salinity, moderate turbidity, and no significant contaminant levels. These inflows provided a net benefit to aqueduct water quality when they occurred.

8.5.3.2 Groundwater Discharges

Conclusion a: Groundwater of unknown quality is pumped from the west side of the aqueduct to protect liner integrity. Groundwater pump-ins from the east did not occur during 1996 to 1999.

Conclusion b: Groundwater has also been pumped into the aqueduct to better manage local water supplies during drought emergencies. Although there were no pump-ins during 1996 to 1999, they remain a significant potential source of salinity and arsenic to the California Aqueduct.

> **Recommendation:** In establishing its policies directing groundwater pump-ins to the SWP, the effects of such operations on the quality of drinking water supplies should be fully addressed and this quality adequately protected.

8.5.3.3 Recreation

Conclusion a: There are 10 designated fishing areas; however, fishing activity has been observed at numerous undesignated locations. There is no contact recreation allowed in the aqueduct. These sites pose a moderate risk of pathogen contamination to the aqueduct.

8.5.3.4 Accidents/Spills

Conclusion a: In June of 1999, two oil releases were reported at Chrisman Pumping Plant. On the 1st occasion, approximately 280 gallons of hydraulic oil were released into the No. 1 discharge line. Several other potentially contaminating accidents/spills took place during 1996 to 1999, including a blacktop roller that tipped over in the aqueduct, a truck accident on an I-5 overcrossing and an incident of deliberate dumping of mulch and paper into the aqueduct. In all cases, proper measures were taken to control the spills and remove the substances from the water. Overall, accidents and spills have posed a minor to moderate threat to water quality in the aqueduct.

> **Recommendation:** DWR should review emergency spill procedures to determine if they are adequate to address future population and traffic growth along this section of the California Aqueduct.

CHAPTER 9 COASTAL BRANCH AQUEDUCT

9.3.4 ANIMAL POPULATIONS

Conclusion a: Field surveys have noted areas where aqueduct fencing is missing which could allow cattle access to the aqueduct. Cattle are a potential source of pathogen and nutrient contamination.

> **Recommendation:** Fencing in the area near mile 13.1 should be repaired.

9.3.6 AGRICULTURAL ACTIVITIES

Conclusion a: Field inspections have identified agricultural turnouts lacking backflow prevention devices and areas where runoff from cattle grazing areas is entering the aqueduct. Agrichemicals are commonly added at turnouts, creating the potential for aqueduct contamination. Cattle grazing is common in the area surrounding the Coastal Branch and can be a significant source of contamination.

Recommendation: DWR should investigate the adequacy of backflow prevention devices at established turnouts along the 15-mile canal section of the Coastal Branch Aqueduct.

Recommendation: A topographical review of the area near mile 7.13 to 7.25 should be conducted to determine if runoff from cattle grazing areas can reach the canal and whether drainage should be corrected.

9.3.7 ALGAL BLOOMS

Conclusion a: Algal blooms have caused taste and odor problems at the Polonio Pass Water Treatment Plant. To control these problems, aqueduct treatment and additional water treatment have been required.

Recommendation: DWR should implement a seasonal sampling program to monitor algal growth in canal and forebays along the Coastal Branch Aqueduct. Seasonal occurrences of nuisance algal growth should be studied in order to design more effective treatment regimes.

9.3.8 UNAUTHORIZED ACTIVITIES

Conclusion a: Field inspections have revealed instances of portable pumps removing water from the aqueduct, and some of these pumps lacked backflow prevention devices. Injection of agrichemicals at these pumps is a potential source of nutrient and pesticide contamination.

Recommendation: DWR should investigate the adequacy of backflow prevention devices at portable pump sites used to remove water from the 15-mile canal section of the Coastal Branch Aqueduct.

OTHER: DEFERRED MAINTENANCE

Conclusion a: Deteriorating sandbags along the west side of the aqueduct at mile 5.65 have been identified, and cracked and buckled canal panels were at mile 1.5 to 2.2.

Recommendation: The sandbags should be removed, and the damaged sections of the canal repaired. These conditions were noted in *Sanitary Survey Update 1996*, but as of March 2001 the work had not been completed.

OTHER: HIGH IRON AND ALUMINUM VALUES AT POLONIO PASS WTP

Conclusion a: Iron and aluminum values for SWP water at Polonio Pass WTP are much higher than at Check 21 of the California Aqueduct. Differences in concentrations for these stations could indicate a source of trace metals along the Coastal Branch Aqueduct or result from analytical errors.

Recommendation: QA/QC procedures for trace metals analysis by participating laboratories should be reviewed. Interlaboratory comparisons using standard references materials should be conducted between Central Coast Water Authority (CCWA) and DWR laboratories.

Recommendation: If the apparent differences in iron and aluminum concentrations are verified, DWR should make the effort to locate possible sources of iron and aluminum along the Coastal Branch Aqueduct.

CHAPTER 10 EAST-AND WEST BRANCHES OF THE CALIFORNIA AQUEDUCT

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: There were limited data to evaluate water quality conditions in the open canal sections of the East and West Branches of the California Aqueduct. Monitoring data for the East Branch of the aqueduct are collected quarterly. There are no routine monitoring data for the West Branch of the aqueduct. Available information indicates that taste and odor problems caused by algal growth are a problem in the East Branch during periods of low aqueduct flow and warm weather.

Recommendation: DWR should prepare a proactive plan for increased algal growth monitoring and treatment as required to reduce the taste and odor problem when low flows are predicted during the warm season.

Recommendation: DWR should improve access to existing water quality data. Water quality data from the existing continuous recording stations at East Branch (Check 41, 66, and Devil Canyon) should be made available on a real-time as well as historical basis to promote better evaluations of the SWP water quality conditions. Presently only

current and prior month data are available online. Use of the existing California Data Exchange Center to receive telemetered data of a longer period of record should be explored.

Recommendation: The Devil Canyon Monitoring Station should be repaired. This station was offline for an extended period.

Conclusion b: Information on recreation and illegal dumping of vehicles is very limited. Their potential impacts on water quality are unknown. Recreation could be a source of pathogens, and vehicles can contribute hydrocarbons.

Recommendation: DWR should review security procedures for sections of the aqueduct that are susceptible to recreational activities and dumping. Perform a limited screening for MTBE and polynuclear aromatic hydrocarbons (PAHs) to determine if they are significant between Pool 53 and 66.

Conclusion c: SWP facilities can discharge hydraulic oils into the aqueduct from accidents or malfunctioning equipment. A few incidents were reported on the East Branch.

Recommendation: Investigate the conversion from petroleum to vegetable oils for use in hydraulic systems. Review facilities and procedures to eliminate discharges to SWP water from DWR installations.

Conclusion d: Urban runoff into the aqueduct continues from the city of Hesperia as reported in *Sanitary Survey Update 1996*. Proposals to mitigate the problem by the San Bernardino County Flood Control District are under review. Possible contaminants in urban runoff include TDS, organic carbon, pesticides, nutrients, pathogens and turbidity.

Recommendation: DWR should maintain awareness of the proposed actions as they are implemented and monitor to verify their effectiveness.

Conclusion e: There were no water quality data for the aqueduct section of the West Branch. However, there is probably little contamination because most of the branch is either pipeline or tunnel. The only potential source is from the 4 square-mile watershed around Quail Lake.

CHAPTER 12 PATHOGENS

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Conclusion a: The use of different approved methods for analyzing coliform densities made comparisons between water treatment plants difficult. In many cases, only qualitative comparisons could be made.

Recommendation: Prior to the next sanitary survey, DHS should recommend the use of coliform methods that allow the direct comparison of coliform data between utilities. Studies should be conducted that examine the potential for inflation of total coliform counts with Colilert™, and also include side-by-side comparisons of the multiple tube fermentation (MTF), Colilert™, and membrane filtration (MF)/subculturing methods under a variety of water quality conditions. Without this, pattern of occurrence data may be the only tool available to compare densities between sites. This approach compromises the ability of all users to quantitatively compare coliform densities spatially and temporally.

Conclusion b: By necessity, much of the protozoan pathogen data used in this update drew upon data analyzed by Information Collection Rule (ICR) methodology. Because of the limitations of the ICR method, robust conclusions cannot be drawn for protozoan pathogen data analyzed in this update.

Conclusion c: With respect to the use of data from the national ICR monitoring program, sample collection did not necessarily correspond to flood or storm events (a period when protozoan mobilization into surface water may be at its highest). This also potentially compromises sanitary survey conclusions drawn from nationwide ICR survey data.

12.2 BACTERIA SUMMARY

Conclusion a: With respect to the agencies profiled, some of the highest total coliform densities occurred at plants receiving South Bay Aqueduct water; however, it is unknown whether this is an artifact of the Colilert™ method. Potential uncertainties associated with the Colilert™ method complicate direct comparisons of total coliform densities.

Recommendation: To determine whether bacteria other than coliforms are counted in the

total coliform assay, Colilert™ needs to be examined further through discussions with the company that markets Colilert™ and investigations of the Colilert™ method in different source water

Recommendation: DHS and utilities should work together to resolve the appropriate methodology for determining total coliforms in source water. Potential over-counts of total coliforms in source water by the Colilert™ method should be resolved prior to the next sanitary survey so that data analyzed for the sanitary survey is comparable across utilities. In the interim, for purposes of the next sanitary survey, utilities should agree on 1 method for total and fecal coliform analysis.

Conclusion b: Total, fecal, and *E. coli* bacteria densities were consistently the lowest for the Southern California treatment plants profiled. Fecal coliform and *E. coli* numbers were also low at the SBA treatment plants. NBA contractors had the highest fecal and *E. coli* numbers.

Conclusion c: Total coliform, fecal coliform, and *E. coli* densities were routinely elevated at the Barker Slough Pumping Plant as well as in the untreated water at a number of NBA water treatment plants. However, direct comparisons between all NBA contractors was hampered by the lack of a consistent method across utilities. This could hamper investigative studies.

Conclusion d: Cattle, which make extensive use of the slough, are the most likely source of fecal contamination for Barker Slough and the NBA. There is a lack of any known septic tank leaks or wastewater treatment plant effluent into the slough (see Chapter 3 for grazing impacts).

Recommendation: Bacterial sources and loads in the watershed should be evaluated. Preventive measures should be taken to keep all livestock out of Barker Slough source water. BMPs should be evaluated to determine if there are cost-effective methods for reducing the load of pathogens to Barker Slough.

Conclusion e: Preliminary analyses suggested that there may be a bacterial contamination problem between the Cordelia Forebay and the City of Napa's Jameson Canyon Water Treatment Plant.

Recommendation: To determine if the preliminary conclusion of contamination between the Cordelia Forebay and the Jameson Canyon WTP is correct, the Benicia, American Canyon and the Jameson Canyon WTPs should, where possible, create sampling schedules that allow direct comparison of coliform data. If analysis of a larger dataset confirms a contamination problem between the Cordelia Forebay and the Jameson Canyon WTP, then, as directed by the data, possible sources of contamination should be investigated. In the interim, potential contamination at the Napa Turnout reservoir should be investigated and all NBA utilities may wish to use the same total and fecal coliform methods to facilitate this and future contamination studies.

Conclusion f: Although fecal and *E. coli* values were low for the SBA contractors, grazing occurs in the Lake Del Valle watershed. Water is not drawn from the reservoir until late summer/fall. Based on climate patterns, contaminant flushing into the lake from the watershed potentially occurs primarily in the winter. This may explain the relatively low densities at the treatment plants when Del Valle water is used in the fall (see Chapter 5, SBA/Lake Del Valle, for hydrology).

Recommendation: To better understand the bacteriological dynamics of Lake Del Valle, a watershed/lake study should be conducted to characterize seasonal pathogen contamination in Lake Del Valle. (See General Recommendations in Chapter 5.)

Conclusion g: There is concern that grazing management practices in the Castaic watershed may contribute to contamination of the reservoir (see Chapter 7, Section 7.2, for livestock impacts).

Recommendation: Discussions should be held with the property owners to ensure preventive measures are in place to reduce the risk of contamination.

Conclusion h: With respect to DWR bacteriological sampling, the highest levels of total coliform, fecal coliform and *E. coli* were observed at the Barker Slough Pumping Plant, while the lowest was observed at the Banks Pumping Plant. Between 1996 and 1999, four sites were sampled for bacteria. The sampling frequency was inadequate to draw conclusions on bacterial levels in the SWP or for comparative purposes with State Water Contractors.

Recommendation: Bacteria numbers can change rapidly. Samples collected once a month are unable to capture actual patterns of bacteria numbers in the SWP. To understand spatial and seasonal patterns, bacteria samples need to be collected more frequently and expanded to key locations along the SWP. This recommendation parallels DHS recommendations regarding the need for more bacteriological sampling within the SWP.

Recommendation: Support DWR Division of Operations and Maintenance evaluation of bacteriological data from the water treatment plants of its 5 field divisions.

12.3 *GIARDIA*

Conclusion a: If Colilert™ overcounts total coliform densities, then the guideline linking total coliform densities to suggested *Giardia* log removals may be inappropriate.

Recommendation: To determine whether bacteria other than coliforms are counted in the total coliform assay, Colilert™ needs to be examined further through discussions with the company that markets Colilert™ and investigations of the Colilert™ method in different source water.

Recommendation: Based on the outcome of the preceding recommendation, DHS should determine if Colilert™ is an appropriate method for use with DHS guidelines of total coliform densities and *Giardia* removal. In lieu of this, for the next sanitary survey utilities should agree on 1 method for total coliform analysis.

Recommendation: If Colilert™ is used to measure total coliform, the use of fecal or *E. coli* data may be a more useful indicator of whether the *Giardia* log removal guideline is appropriate.

Conclusion b: No correlation has been found between total coliform and *Giardia* densities.

Recommendation: DHS should re-examine the validity of using total coliform as a surrogate organism for suggesting additional *Giardia* log removals. Source water protection may be a more valuable tool than quantitative guidelines based on questionable relationships.

Conclusion c: Based on *Giardia* data collected from EPA's nationwide ICR, median *Giardia* concentrations were all below the detection limit.

Conclusion d: Ambient *Giardia* concentrations are still open to question. Future analysis using Method 1623 may reach different conclusions then those generated from ICR data.

Conclusion e: Frequency of occurrence data suggest that *Giardia* concentrations may be higher in Barker Slough in the winter.

Recommendation: Cattle are present in the watershed during the winter rainy season and have been observed defecating in the slough. Proactive steps should be taken to keep livestock out of the slough. Since *Giardia* analysis is still questionable, the effect of restricting livestock access to the slough should be monitored in the winter before and after exclusion through daily *E. coli* sampling.

12.4 *CRYPTOSPORIDIUM*

Conclusion a: ICR data suggest that all WTPs profiled would fall into the first bin of *Cryptosporidium* log removals. If Interim Enhanced Surface Water Treatment Rule (IESWTR) and Stage 2 requirements were met, this could mean that no additional log removals would be required of the plants profiled. However, results were generated using questionable ICR data.

Recommendation: Based on the weaknesses of the ICR method, it would be premature to draw any final conclusions on utilities' *Cryptosporidium* concentrations and levels of log removals. Future sanitary surveys using Method 1623 may identify different bin classifications.

12.6 STUDIES OF HEALTH RISKS FROM BODY CONTACT RECREATION IN SOUTHERN CALIFORNIA SWP RESERVOIRS

Conclusion a: Depending on the cumulative probability used and the 3-log removal requirement of the LT2 ESWTR, infections from *Cryptosporidium* at DWR's 4 Southern California reservoirs could be below EPA target level of risk. In the original report, only a 2-log removal was assumed, and Perris and Castaic lakes were above EPA target risk levels (see Appendix A).

Recommendation: Similar risk assessments should be conducted at other SWP source reservoirs, including San Luis Reservoir and Lake Del Valle using the 3-log removal assumption.

Conclusion b: Michael Anderson's health risk report to the State Water Contractors did not resolve the issue of whether rotavirus is a risk to human health in the reservoirs modeled (see Appendix A). The data for modeling health risks for rotavirus are contradictory and/or limited precluding a robust risk analysis.

Recommendation: If rotavirus is considered a health risk in the reservoirs, then a monitoring program with field studies should be created to investigate rotavirus concentrations.

12.7 PROTOZOAN SAMPLING METHOD CONCERNS

Conclusion a: Sampling of the SWP with the ICR method suggested that *Cryptosporidium* and *Giardia* are more prevalent in the Delta and its tributaries than in the SWP aqueduct and reservoirs, and they occur more frequently and at higher concentrations during flood and storm events. However, the ICR method exhibited poor recovery, accuracy, and precision. Therefore, it is impossible to know whether these results are accurate.

Recommendation: The ICR method should not be used to assess concentrations of *Cryptosporidium* and *Giardia* in Delta source waters.

Conclusion b: Better recoveries for *Giardia* and *Cryptosporidium* were obtained using EPA's Method 1623 over the ICR method. However, experiments using Method 1623 did not examine whether matrix effects caused recovery variability.

Conclusion c: Differences in *Cryptosporidium* recovery, independent of turbidity, suggest other factors may be influencing Method 1623 recoveries. Detection limits also appeared to vary with the water tested.

Recommendation: More studies using Method 1623 should be conducted before this method is used for large-scale source water sampling of the SWP. The studies should be conducted to evaluate whether the method is valid in SWP source waters during suspected periods of high pathogen transport in the watersheds, for example, storm events.

Recommendation: The EPA should be strongly encouraged to further improve the accuracy, sensitivity, and precision of Method 1623 (or develop a new method) that allows for more robust assessments of pathogens for source water monitoring.